



**THE DATASHEET OF
DS36C278MX**



DS36C278 Low Power Multipoint EIA-RS-485 Transceiver

Check for Samples: [DS36C278](#)

FEATURES

- **100% RS-485 Compliant**
 - **Guaranteed RS-485 Device Interoperation**
- **Low Power CMOS Design: I_{CC} 500 μ A Max**
- **Built-In Power Up/Down Glitch-Free Circuitry**
 - **Permits Live Transceiver Insertion/Displacement**
- **PDIP and SOIC Packages Available**
- **Industrial Temperature Range: -40°C to $+85^{\circ}\text{C}$**
- **On-Board Thermal Shutdown Circuitry**
 - **Prevents Damage to the Device in the Event of Excessive Power Dissipation**
- **Wide Common Mode Range: -7V to $+12\text{V}$**
- **Receiver Open Input Fail-Safe ⁽¹⁾**
- **$\frac{1}{4}$ Unit Load (DS36C278): ≥ 12 Nodes**
- **$\frac{1}{2}$ Unit Load (DS36C278T): ≥ 64 Nodes**
- **ESD (Human Body Model): ≥ 2 kV**
- **Drop in Replacement for:**
 - **LTC485, MAX485, DS75176, DS3695**

⁽¹⁾ Non-terminated, open input only

Connection Diagram

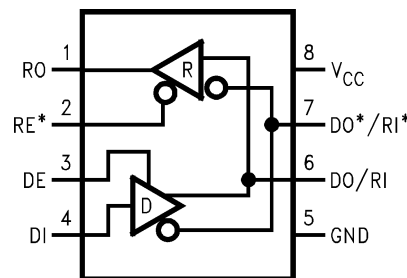


Figure 1. 8-Pin PDIP or SOIC Package Numbers D0008A and P0008E

DESCRIPTION

The DS36C278 is a low power differential bus/line transceiver designed to meet the requirements of RS-485 standard for multipoint data transmission. In addition it is compatible with TIA/EIA-422-B.

The CMOS design offers significant power savings over its bipolar and ALS counterparts without sacrificing ruggedness against ESD damage. The device is ideal for use in battery powered or power conscious applications. I_{CC} is specified at 500 μ A maximum.

The driver and receiver outputs feature TRI-STATE capability. The driver outputs operate over the entire common mode range of -7V to $+12\text{V}$. Bus contention or fault situations that cause excessive power dissipation within the device are handled by a thermal shutdown circuit, which forces the driver outputs into the high impedance state.

The receiver incorporates a fail safe circuit which guarantees a high output state when the inputs are left open. ⁽¹⁾

The DS36C278T is fully specified over the industrial temperature range (-40°C to $+85^{\circ}\text{C}$).



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Pin Descriptions

| Pin No. | Name | Description |
|---------|-------------|--|
| 1 | RO | Receiver Output: When RE (Receiver Enable) is LOW, the receiver is enabled (ON), if $DO/RI \geq DO^*/RI^*$ by 200 mV, RO will be HIGH. If $DO/RI \leq DO^*/RI^*$ by 200 mV, RO will be LOW. Additionally RO will be HIGH for OPEN (Non-terminated) Inputs. |
| 2 | RE* | Receiver Output Enable: When RE* is LOW the receiver output is enabled. When RE* is HIGH, the receiver output is in TRI-STATE (OFF). |
| 3 | DE | Driver Output Enable: When DE is HIGH, the driver outputs are enabled. When DE is LOW, the driver outputs are in TRI-STATE (OFF). |
| 4 | DI | Driver Input: When DE (Driver Enable) is HIGH, the driver is enabled, if DI is LOW, then DO/RI will be LOW and DO^*/RI^* will be HIGH. If DI is HIGH, then DO/RI is HIGH and DO^*/RI^* is LOW. |
| 5 | GND | Ground Connection. |
| 6 | DO/RI | Driver Output/Receiver Input, 485 Bus Pin. |
| 7 | DO^*/RI^* | Driver Output/Receiver Input, 485 Bus Pin. |
| 8 | V_{CC} | Positive Power Supply Connection: Recommended operating range for V_{CC} is +4.75V to +5.25V. |

Table 1. Truth Table⁽¹⁾

| DRIVER SECTION | | | | |
|------------------|----|---------------------|-------|-------------|
| RE* | DE | DI | DO/RI | DO^*/RI^* |
| X | H | H | H | L |
| X | H | L | L | H |
| X | L | X | Z | Z |
| RECEIVER SECTION | | | | |
| RE* | DE | RI-RI* | RO | |
| L | L | $\geq +0.2V$ | H | |
| L | L | $\leq -0.2V$ | L | |
| H | L | X | Z | |
| L | L | OPEN ⁽¹⁾ | H | |

(1) Non-terminated, open input only



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings⁽¹⁾⁽²⁾

| | |
|---|------------------------------|
| Supply Voltage (V_{CC}) | +12V |
| Input Voltage (DE, RE*, & DI) | -0.5V to ($V_{CC} + 0.5V$) |
| Common Mode (V_{CM}) | |
| Driver Output/Receiver Input | $\pm 15V$ |
| Input Voltage (DO/RI , DO^*/RI^*) | $\pm 14V$ |
| Receiver Output Voltage | -0.5V to ($V_{CC} + 0.5V$) |
| Maximum Package Power Dissipation | |
| @ +25°C | |
| D0008A Package 1190 mW, derate | 9.5 mW/°C above +25°C |
| P0008E Package 744 mW, derate | 6.0 mW/°C above +25°C |
| Storage Temperature Range | -65°C to +150°C |
| Lead Temperature (Soldering 4 sec) | +260°C |

- (1) "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The table of "Electrical Characteristics" specifies conditions of device operation.
- (2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.

Recommended Operating Conditions

| | Min | Typ | Max | Units |
|--|-------|------|-------|-------|
| Supply Voltage (V_{CC}) | +4.75 | +5.0 | +5.25 | V |
| Bus Voltage | -7 | | +12 | V |
| Operating Free-Air Temperature (T_A) | | | | |
| DS36C278T | -40 | 25 | +85 | °C |
| DS36C278 | 0 | 25 | +70 | °C |

Electrical Characteristics ⁽¹⁾ ⁽²⁾

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified

| Parameter | | Test Conditions | Reference | Min | Typ | Max | Units | |
|--|---|--|-------------------|-----------------|--------|-----------|------------|----|
| DIFFERENTIAL DRIVER CHARACTERISTICS | | | | | | | | |
| V_{OD1} | Differential Output Voltage | $I_O = 0$ mA (No Load) | (422) (485) | 1.5 | | 5.0 | V | |
| V_{OD0} | Output Voltage | $I_O = 0$ mA | | 0 | | 5.0 | V | |
| V_{OD0^*} | Output Voltage | (Output to GND) | | 0 | | 5.0 | V | |
| V_{OD2} | Differential Output Voltage (Termination Load) | $R_L = 50\Omega$ | (422) | Figure 2 | 2.0 | 2.8 | V | |
| | | $R_L = 27\Omega$ | (485) | | 1.5 | 2.3 | 5.0 | V |
| ΔV_{OD2} | Balance of V_{OD2} $ V_{OD2} - V_{OD2^*} $ | $R_L = 27\Omega$ or 50Ω | (3) | | -0.2 | 0.1 | +0.2 | V |
| | | | (422, 485) | | | | | |
| V_{OD3} | Differential Output Voltage (Full Load) | $R_1 = 54\Omega$, $R_2 = 375\Omega$ $V_{TEST} = -7V$ to $+12V$ | Figure 3 | | 1.5 | 2.0 | 5.0 | V |
| V_{OC} | Driver Common Mode Output Voltage | $R_L = 27\Omega$ | (485) | Figure 2 | 0 | | 3.0 | V |
| | | $R_L = 50\Omega$ | (422) | | 0 | | 3.0 | V |
| ΔV_{OC} | Balance of V_{OC} $ V_{OC} - V_{OC^*} $ | $R_L = 27\Omega$ or $R_L = 50\Omega$ | (3) (422, 485) | | -0.2 | | +0.2 | V |
| I_{OSD} | Driver Output Short-Circuit Current | $V_O = +12V$ | (485) | | 200 | +250 | mA | |
| | | $V_O = -7V$ | (485) | | -190 | -250 | mA | |
| RECEIVER CHARACTERISTICS | | | | | | | | |
| V_{TH} | Differential Input High Threshold Voltage | $V_O = V_{OH}$, $I_O = -0.4V$ $-7V \leq V_{CM} \leq +12V$ | (4) | | +0.035 | +0.2 | V | |
| V_{TL} | Differential Input Low Threshold Voltage | $V_O = V_{OL}$, $I_O = 0.4$ mA $-7V \leq V_{CM} \leq +12V$ | (422, 485) | -0.2 | -0.035 | | V | |
| V_{HST} | Hysteresis | $V_{CM} = 0V$ | (5) | | 70 | | mV | |
| R_{IN} | Input Resistance | $-7V \leq V_{CM} \leq +12V$ | DS36C278T | 24 | 68 | | k Ω | |
| R_{IN} | Input Resistance | $-7V \leq V_{CM} \leq +12V$ | DS36C278 | 48 | 68 | | k Ω | |
| I_{IN} | Line Input Current (6) | Other Input = 0V, | DS36C278 | $V_{IN} = +12V$ | 0 | 0.19 | 0.25 | mA |
| | | $DE = V_{IL}$, $RE^* = V_{IL}$, | | $V_{IN} = -7V$ | 0 | -0.1 | -0.2 | mA |
| | | $V_{CC} = 4.75$ to 5.25 | DS36C278T | $V_{IN} = +12V$ | 0 | 0.19 | 0.5 | mA |
| | | or 0V | | $V_{IN} = -7V$ | 0 | -0.1 | -0.4 | mA |
| I_{ING} | Line Input Current Glitch (6) | Other Input = 0V, | DS36C278 | $V_{IN} = +12V$ | 0 | 0.19 | 0.25 | mA |
| | | $DE = V_{IL}$, $RE^* = V_{IL}$, | | $V_{IN} = -7V$ | 0 | -0.1 | -0.2 | mA |
| | | $V_{CC} = +3.0V$ or $0V$, | DS36C278T | $V_{IN} = +12V$ | 0 | 0.19 | 0.5 | mA |
| | | $T_A = 25^\circ C$ | | $V_{IN} = -7V$ | 0 | -0.1 | -0.4 | mA |
| I_B | Input Balance Test | $RS = 500\Omega$ | (422) (7) | | | ± 400 | mV | |

- (1) Current into device pins is defined as positive. Current out of device pins is defined as negative. All voltages are referenced to ground except V_{OD1} and V_{OD2} .
- (2) All typicals are given for: $V_{CC} = +5.0V$, $T_A = +25^\circ C$.
- (3) Delta $|V_{OD2}|$ and Delta $|V_{OC}|$ are changes in magnitude of V_{OD2} and V_{OC} , respectively, that occur when input changes state.
- (4) Threshold parameter limits specified as an algebraic value rather than by magnitude.
- (5) Hysteresis defined as $V_{HST} = V_{TH} - V_{TL}$.
- (6) I_{IN} includes the receiver input current and driver TRI-STATE leakage current.
- (7) For complete details of test, see RS-485.

Electrical Characteristics ⁽¹⁾ ⁽²⁾ (continued)

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified

| Parameter | | Test Conditions | | Reference | Min | Typ | Max | Units |
|-------------------------------|---------------------------|--|----------------------|-------------------|-----|-----|-----------------|-------|
| V _{OH} | High Level Output Voltage | I _{OH} = -4 mA, V _{ID} = +0.2V | | RO Figure 12 | 3.5 | 4.6 | | V |
| V _{OL} | Low Level Output Voltage | I _{OL} = +4 mA, V _{ID} = -0.2V | | | | 0.3 | 0.5 | V |
| I _{OSR} | Short Circuit Current | V _O = GND | | RO | 7 | 35 | 85 | mA |
| I _{OZR} | TRI-STATE Leakage Current | V _O = 0.4V to 2.4V | | | | | ±1 | µA |
| DEVICE CHARACTERISTICS | | | | | | | | |
| V _{IH} | High Level Input Voltage | | | DE, RE*, DI | 2.0 | | V _{CC} | V |
| V _{IL} | Low Level Input Voltage | | | | GND | | 0.8 | V |
| I _{IH} | High Level Input Current | V _{IH} = V _{CC} | | | | | 2 | µA |
| I _{IL} | Low Level Input Current | V _{CC} = 5V | V _{IL} = 0V | | | | -2 | µA |
| | | V _{CC} = +3.0V | | | | -2 | µA | |
| I _{CC} | Power Supply Current | Driver and Receiver ON | | V _{CC} | | 200 | 500 | µA |
| I _{CCR} | (No Load) | Driver OFF, Receiver ON | | | | 200 | 500 | µA |
| I _{CCD} | | Driver ON, Receiver OFF | | | | 200 | 500 | µA |
| I _{CCZ} | | Driver and Receiver OFF | | | | 200 | 500 | µA |

Switching Characteristics ⁽¹⁾ ⁽²⁾

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified

| Parameter | | Test Conditions | | Reference | Min | Typ | Max | Units |
|---------------------------------|---|---|--|------------------------------------|-----|-----|-----|-------|
| DRIVER CHARACTERISTICS | | | | | | | | |
| t _{PHLD} | Differential Propagation Delay High to Low | R _L = 54Ω, C _L = 100 pF | | Figure 7 | 10 | 39 | 80 | ns |
| t _{PLHD} | Differential Propagation Delay Low to High | | | | 10 | 40 | 80 | ns |
| t _{SKD} | Differential Skew t _{PHLD} - t _{PLHD} | | | | 0 | 1 | 10 | ns |
| t _r | Rise Time | | | | 3 | 25 | 50 | ns |
| t _f | Fall Time | | | | 3 | 25 | 50 | ns |
| t _{PHZ} | Disable Time High to Z | C _L = 15 pF | | Figure 8, Figure 9 | — | 80 | 200 | ns |
| t _{PLZ} | Disable Time Low to Z | RE * = L | | Figure 10, Figure 11 | — | 80 | 200 | ns |
| t _{PZH} | Enable Time Z to High | C _L = 100 pF | | Figure 8, Figure 9 | — | 50 | 200 | ns |
| t _{PZL} | Enable Time Z to Low | RE * = L | | Figure 10, Figure 11 | — | 65 | 200 | ns |
| RECEIVER CHARACTERISTICS | | | | | | | | |
| t _{PHL} | Propagation Delay High to Low | C _L = 15 pF | | Figure 13, Figure 14 | 30 | 210 | 400 | ns |
| t _{PLH} | Propagation Delay Low to High | | | | 30 | 190 | 400 | ns |
| t _{SK} | Skew, t _{PHL} - t _{PLH} | | | | 0 | 20 | 50 | ns |
| t _{PLZ} | Output Disable Time | C _L = 15 pF | | Figure 15, Figure 16, Figure 17 | — | 50 | 150 | ns |
| t _{PHZ} | | | | | — | 55 | 150 | ns |
| t _{PZL} | Output Enable Time | | | | — | 40 | 150 | ns |
| t _{PZH} | | | | | — | 45 | 150 | ns |

(1) All typicals are given for: V_{CC} = +5.0V, T_A = +25°C.

(2) C_L includes probe and jig capacitance.

PARAMETER MEASUREMENT INFORMATION

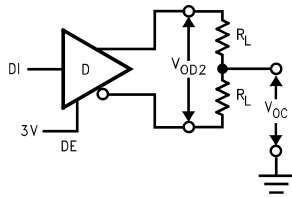


Figure 2. Driver V_{OD2} and V_{OC}

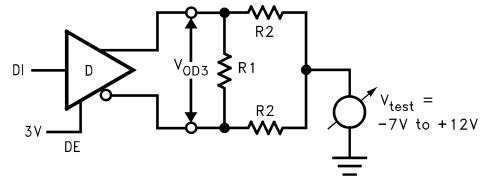
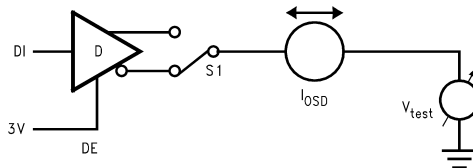


Figure 3. Driver V_{OD3}



Figure 4. Driver V_{OH} and V_{OL}



$V_{test} = -7V$ to $+12V$

Figure 5. Driver I_{OSD}

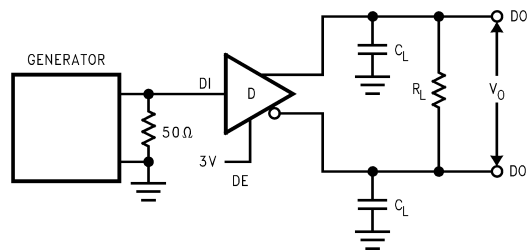


Figure 6. Driver Differential Propagation Delay Test Circuit

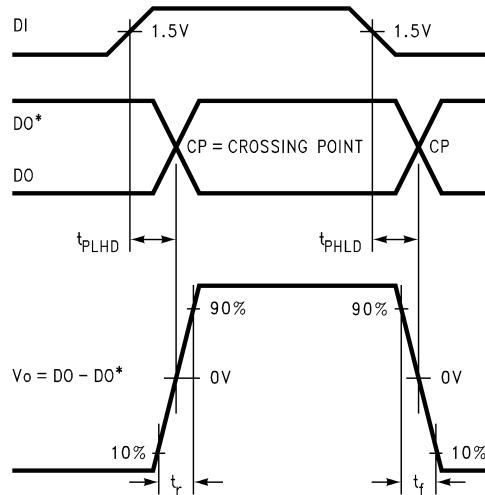


Figure 7. Driver Differential Propagation Delays and Differential Rise and Fall Times

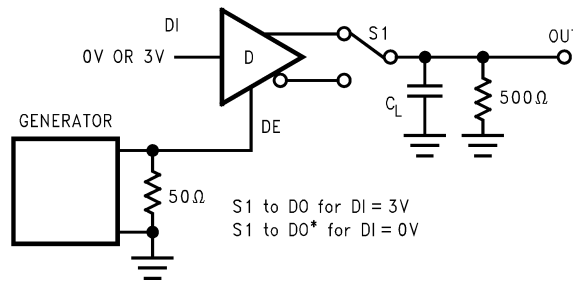


Figure 8. TRI-STATE Test Circuit (t_{PZH} , t_{PHZ})

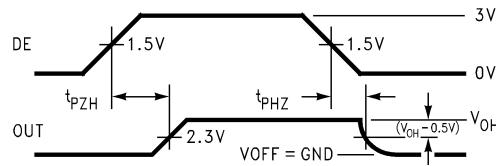


Figure 9. TRI-STATE Waveforms (t_{PZH} , t_{PHZ})

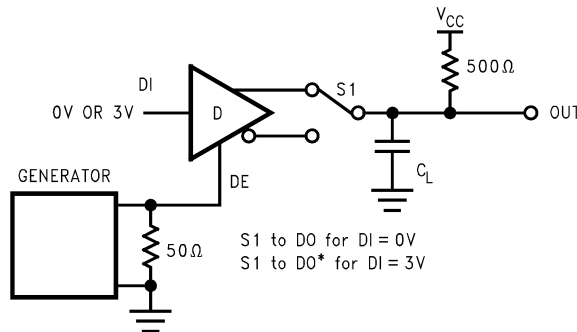


Figure 10. TRI-STATE Test Circuit (t_{PLZL} , t_{PLZ})

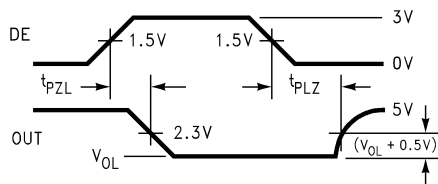


Figure 11. TRI-STATE Waveforms (t_{PZL} , t_{PLZ})

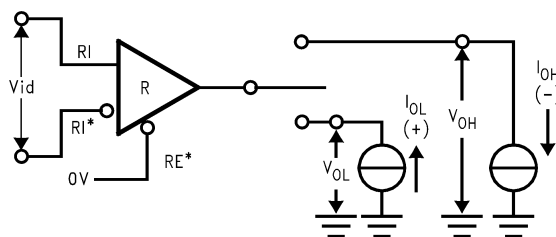


Figure 12. Receiver V_{OH} and V_{OL}

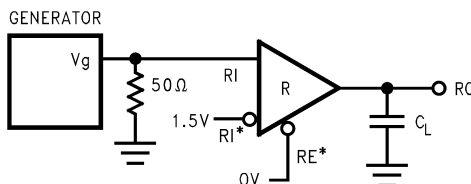


Figure 13. Receiver Differential Propagation Delay Test Circuit

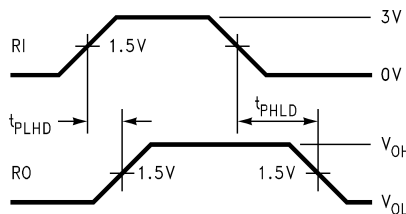


Figure 14. Receiver Differential Propagation Delay Waveforms

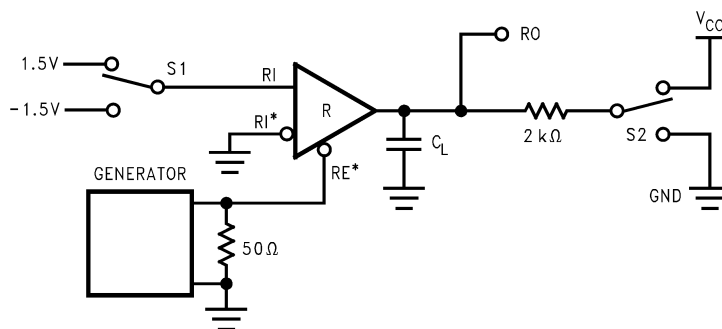


Figure 15. Receiver TRI-STATE Test Circuit

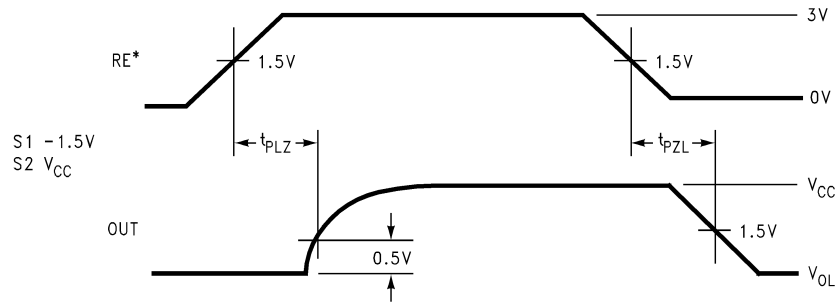


Figure 16. Receiver Enable and Disable Waveforms (t_{PLZ} , t_{PZL})

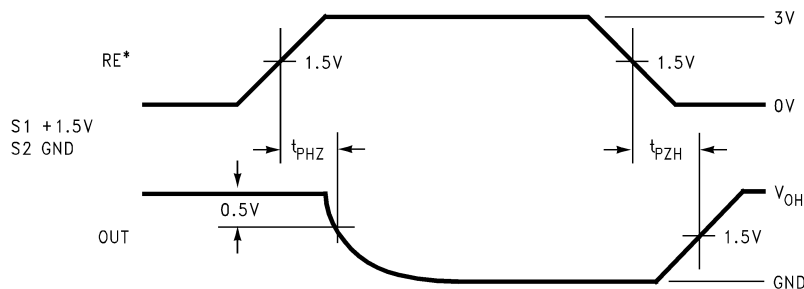


Figure 17. Receiver Enable and Disable Waveforms (t_{PHZ} , t_{PZH})

Typical Application Information

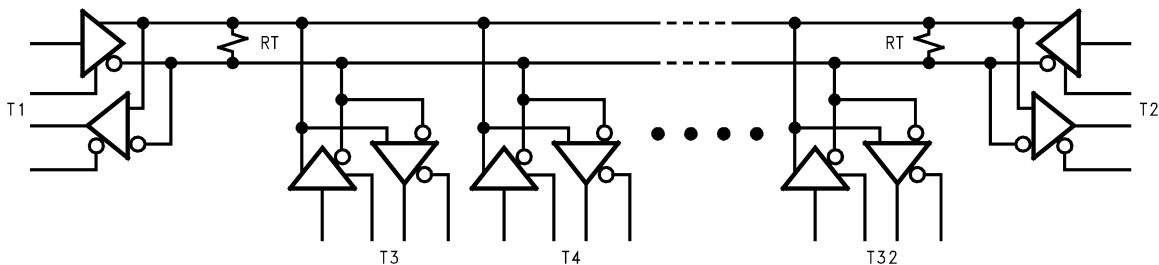


Figure 18. Typical RS-485 Bus Interface

Unit Load

A unit load for an RS-485 receiver is defined by the input current versus the input voltage curve. The gray shaded region is the defined operating range from -7V to $+12\text{V}$. The top border extending from -3V at 0 mA to $+12\text{V}$ at $+1\text{ mA}$ is defined as one unit load. Likewise, the bottom border extending from $+5\text{V}$ at 0 mA to -7V at -0.8 mA is also defined as one unit load (see Figure 19). An RS-485 driver is capable of driving up to 32 unit loads. This allows up to 32 nodes on a single bus. Although sufficient for many applications, it is sometimes desirable to have even more nodes. For example, an aircraft that has 32 rows with 4 seats per row would benefit from having 128 nodes on one bus. This would allow signals to be transferred to and from each individual seat to 1 main station. Usually there is one or two less seats in the last row of the aircraft near the restrooms and food storage area. This frees the node for the main station.

The DS36C278, the DS36C279, and the DS36C280 all have $\frac{1}{2}$ unit load and $\frac{1}{4}$ unit load (UL) options available. These devices will allow up to 64 nodes or 128 nodes guaranteed over temperature depending upon which option is selected. The $\frac{1}{2}$ UL option is available in industrial temperature and the $\frac{1}{4}$ UL is available in commercial temperature.

First, for a $\frac{1}{2}$ UL device the top and bottom borders shown in Figure 19 are scaled. Both 0 mA reference points at +5V and -3V stay the same. The other reference points are +12V at +0.5 mA for the top border and -7V at -0.4 mA for the bottom border (see Figure 19). Second, for a $\frac{1}{4}$ UL device the top and bottom borders shown in Figure 19 are scaled also. Again, both 0 mA reference points at +5V and -3V stay the same. The other reference points are +12V at +0.25 mA for the top border and -7V at -0.2 mA for the bottom border (see Figure 19).

The advantage of the $\frac{1}{2}$ UL and $\frac{1}{4}$ UL devices is the increased number of nodes on one bus. In a single master multi-slave type of application where the number of slaves exceeds 32, the DS36C278/279/280 may save in the cost of extra devices like repeaters, extra media like cable, and/or extra components like resistors.

The DS36C279 and DS36C280 have an additional feature which offers more advantages. The DS36C279 has an automatic sleep mode function for power conscious applications. The DS36C280 has a slew rate control for EMI conscious applications. Refer to the sleep mode and slew rate control portion of the application information section in the corresponding datasheet for more information on these features.

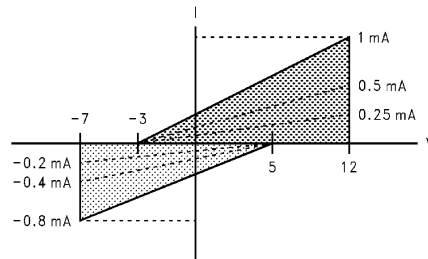


Figure 19. Input Current vs Input Voltage Operating Range

REVISION HISTORY

| Changes from Revision B (April 2013) to Revision C | Page |
|--|-------------------|
| • Changed layout of National Data Sheet to TI format | 9 |

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|---------|
| DS36C278M/NOPB | LIFEBUY | SOIC | D | 8 | 95 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | 0 to 70 | DS36C 278M | |
| DS36C278MX/NOPB | LIFEBUY | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | 0 to 70 | DS36C 278M | |
| DS36C278TM | LIFEBUY | SOIC | D | 8 | 95 | TBD | Call TI | Call TI | 0 to 70 | 36C27 8TM | |
| DS36C278TM/NOPB | LIFEBUY | SOIC | D | 8 | 95 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | 0 to 70 | 36C27 8TM | |
| DS36C278TMX | LIFEBUY | SOIC | D | 8 | 2500 | TBD | Call TI | Call TI | 0 to 70 | 36C27 8TM | |
| DS36C278TMX/NOPB | NRND | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU SN | Level-1-260C-UNLIM | 0 to 70 | 36C27 8TM | |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

⁽⁶⁾ Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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